HORSLEY DRIVE BUSINESS PARK CUSTOMER FULFILMENT CENTRE

Noise and Vibration Impact Assessment

Prepared for:

FDC Construction & Fitout Pty Ltd
22 - 24 Junction Street,
Forest Lodge, NSW 2037

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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Grd Floor, 2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100
E: sydney@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with FDC Construction & Fitout Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.19222-R03-v1.0	13 February 2020	Minh Nguyen	Robert Hall	Antony Williams

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1 Introduction

FDC Construction & Fitout Pty Ltd (FDC) on behalf of Supermarkets proposes a large-scale warehousing and distribution facility at the Horsley Drive Business Park (HDBP) Stage 2, located west of Cowpasture Road, NSW.

1.1 Background

Horsley Drive Business Park is a cluster of regional business hubs located in Western Sydney Parkland (WSP) situated around 1.5 km to the east of the M7 Motorway and immediately west of Wetherill Park Industrial Precinct. HDBP Stage 2 (the site) is situated to the north of the recently constructed HDBP Stage 1, with frontages along Cowpasture Road to the east and Trivet Street to the north-east.

Construction noise and vibration impacts from the project were previously assessed as part of the *Horsley Park Business Park – Stage 2, DA Acoustic Assessment* prepared by Acoustic Logic in 2016.

The Concept Proposal for HDBP Stage 2 obtained Development Consent (SSD 7664), on 9 November 2017 from the Department of Planning and Environment.

The proposed development of the individual lots, buildings and structures associated with future uses is subject to separate development applications.

1.2 Subject Site

The Proposal consists of construction and operation of a 24-hour warehouse and distribution centre, encompassing offices, car parking, delivery vehicle unloading and loading areas, landscaping and supporting infrastructure within the HDBP.

The site is located within Lots 17-22 DP 13961 and Lot 2 DP 1212087 within the HDBP. The site is within the Fairfield local government area.

1.3 Purpose of this Report

SLR Consulting Australia Pty Ltd (SLR) has been engaged by FDC to prepare an Operational Noise Impact Assessment for the Proposal.

The aims of this assessment are to:

- summarise the operational noise assessment for the Proposal
- identify feasible and reasonable noise mitigation and management measures to be incorporated in the detailed design and construction planning stage of the Proposal.

This assessment forms part of the input to the Development Application (DA) for the Proposal.

1.4 Terminology

Specific acoustic terminology is used in this report. An explanation of common acoustic terms is provided in **Appendix A**.

2 Assessment Requirements

2.1 HDBP Stage 2 Development Consent - SDD 7664

Conditions for the consent of State Significant Development (SDD) application 7664 are shown below.

B12. For all future development at the site, noise generated during operations must not exceed the noise limits outlined in Table 3 when measured at the property located at 28 Trivet Street, Wetherill Park.

Table 3: Noise Limits dB(A)

Location	Day $L_{Aeq(15\ minute)}$	Evening $L_{Aeq(15\ minute)}$	Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$
28 Trivet Street, Wetherill Park	52	49	47	57

***Note**: Noise is to be measured in accordance with the relevant procedures and exemptions (including certain meteorological conditions) of the NSW Industrial Noise Policy.*

B13. If the construction of an acoustic barrier is required to achieve the noise limits in Condition B12 above, the barrier must be maintained as required and comprise a density of at least 10-15 kg/m².

The assessment property (residential receiver at 28 Trivet Street) is located to the east of the site and identified in **Section 3.1**.

2.2 Secretary's Environmental Assessment Requirements – SSD10404

The NSW Department of Planning Industry and Environment (DPE) have issued a list of Secretary's Environmental Assessment Requirements (SEARs) which inform the assessment. The SEARs which are specific to the noise impact assessment for the Proposal are shown in **Table 1**.

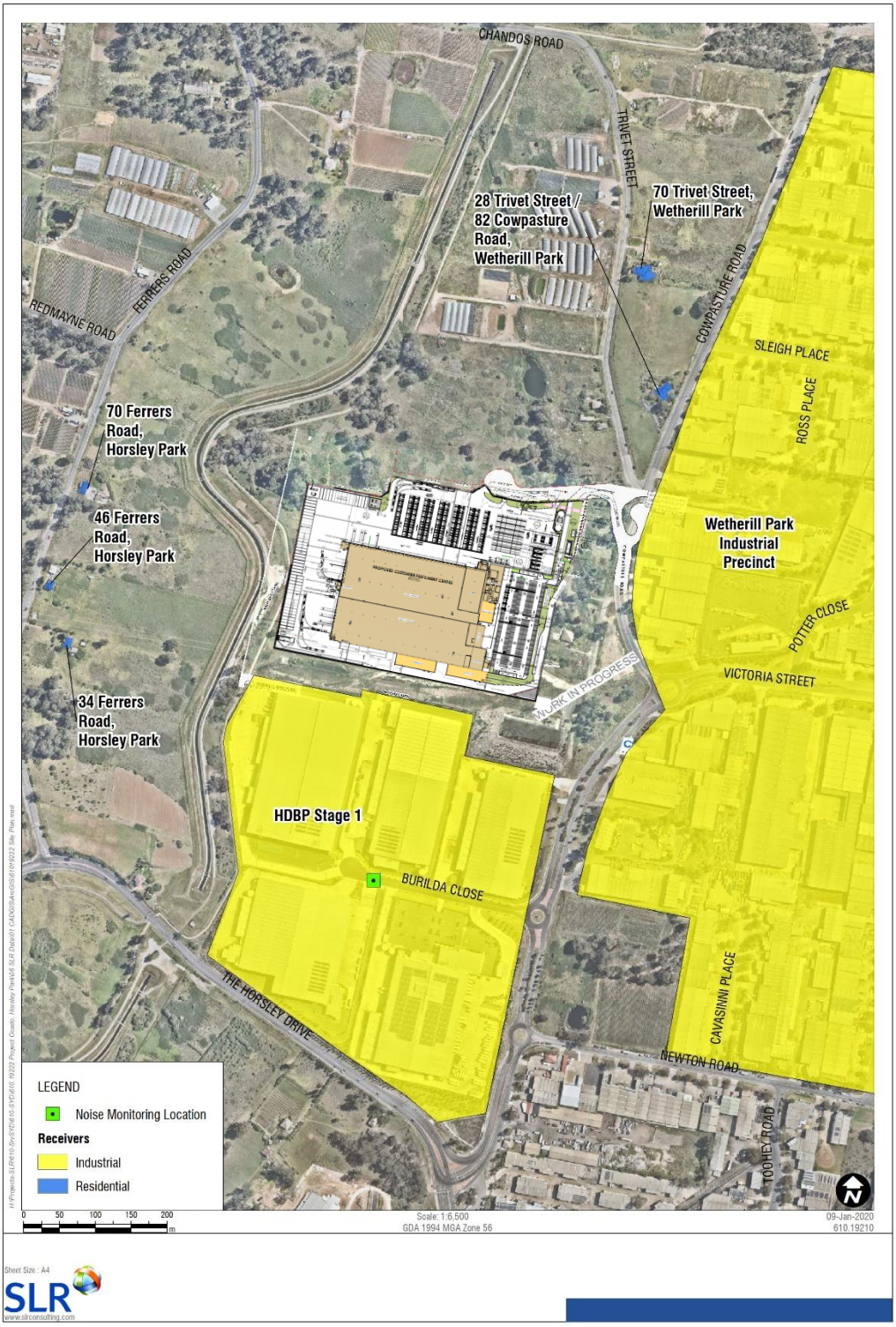
Table 1 Secretary's Environmental Assessment Requirements, SDD10404, 18 December 2019

4. Noise and Vibration
Requirement
- a quantitative noise and vibration impact assessment undertaken by a suitably qualified person in accordance with the relevant Environment Protection Authority (EPA) guidelines and including an assessment of nearby sensitive receivers;
- cumulative impacts of other existing and proposed developments; and
- details of proposed mitigation, management and monitoring measures.

3 Development Description

3.1 Site Location

Figure 1 Site location showing previous noise monitoring site and receivers (Siteplan plotted 31/01/2020)



3.2 Site Activities

The proposed activities identified with potential to contribute to overall site noise emissions are outlined in **Table 2**.

Table 2 Activities Proposed during Operation

Item	Operating Time	Location
Warehouse Operations	4.00am – 12.00am[1]	Contained within the building
Compactors	4.00am – 12.00am	To the west of the main building
Van Wash Bays	5.00am- 5.00pm	To the north of the main building
Mechanical Plant	24 hours	On the main building rooftop and on the plantroom deck

Note 1: 12.00am to 4.00am is a maintenance period

3.3 Hours of Operation

The site is proposed to operate on a 24 hour basis. Refer to **Section 3.2** for the breakdown operational hours of specific activities proposed within the site.

4 Assessment Criteria and Sensitive Receivers

4.1 Identification of Sensitive Receivers

The nearest potentially noise and vibration sensitive receivers to the project were identified in the DA Acoustic Assessment for the HDBP. The location and type of the nearest receivers are shown in **Figure 1** and **Table 3**.

Table 3 Surrounding Sensitive Receivers

Address	Type	Distance (m) from Site Boundary
28 Trivet Street, Wetherill Park (82 Cowpasture Road, Wetherill Park)	Residential	180 m northeast of HDBP Stage 2
34 Ferrers Road, Horsley Park	Residential	250 m west of HDBP Stage 2
46 Ferrers Road, Horsley Park	Residential	300 m west of HDBP Stage 2
70 Ferrers Road, Horsley Park	Residential	230 m west of HDBP Stage 2
HDBP Stage 1	Industrial / Commercial	60 m south of HDBP Stage 2
Wetherill Park Industrial Precinct	Industrial / Commercial	90 m east of HDBP Stage 2

4.2 Assessment Criteria

4.2.1 SDD7664 Conditions of Consent

The consent conditions for the HDBP Stage 2 (as stated in SSD7764 – refer to **Section 2.1**), are shown in **Table 4**.

Table 4 Controlling Noise Assessment Criteria

Location	Day	Evening	Night	Night
	LAeq(15minute)	LAeq(15minute)	LAeq(15minute)	LA1(1minute)
28 Trivet Street, Wetherill Park	52	49	47	57

4.2.2 SDD10404 SEARs criteria

The SEARS requires a noise and vibration impact assessment to be undertaken by a suitably qualified person in accordance with the relevant Environment Protection Authority (EPA) guidelines and including an assessment of nearby sensitive receivers.

4.2.2.1 Noise Policy for Industry

The *Noise Policy for Industry* (NPfI) was released in 2017 and sets out the NSW EPA's requirements for the assessment and management of noise from industry in NSW. The EPA has regulatory responsibility for the control of noise from 'scheduled premises' under the *Protection of the Environment Operations Act 1997*. In implementing the NPfI, the EPA has two broad objectives:

- controlling intrusive noise levels in the short term
- maintaining noise amenity levels for particular land uses over the medium to long-term.

In general terms, the NPfI sets out procedures for establishing the project intrusiveness $L_{Aeq(15minute)}$ and project amenity $L_{Aeq(period)}$ noise levels, with a view to determining the lower (that is, the more stringent) being the Project Trigger Noise Level (PTNL), NPfI Section 2.1 states:

> *The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited and amenity is protected and that no single industry can unacceptably change the noise level of an area.*

For assessing intrusiveness, the existing background noise generally needs to be measured. The intrusiveness trigger level essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than 5 dBA above the measured (or default) Rating Background Level (RBL).

The amenity assessment is based on amenity noise levels specific to the land use and associated activities. The project noise levels relate only to industrial-type noise and do not include road, rail or community-related noise. Based on the NPfI land use descriptions residences surrounding the development have been classified for the purposes of this noise assessment as 'urban'.

For this assessment, the area surrounding the proposal is considered to be 'urban'. The NPfI specifies an 'urban' area as one which:

- is dominated by 'urban hum' or industrial source noise, where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources
- has through-traffic with characteristically heavy and continuous flows during peak periods
- is near commercial districts or industrial districts
- has any combination of the above.

In addition to the PTNLs, NPfI provides guidance in relation to the assessment of sleep disturbance. Specifically, the NPfI states:

> *Where the subject development/premises night-time noise levels at a residential location exceed:*
>
> - $L_{Aeq(15minute)}$ *40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or*
> - L_{AFmax} *52 dBA or the prevailing RBL plus 15 dB, whichever is the greater,*
>
> *a detailed maximum noise level assessment should be undertaken.*

4.2.2.2 NPfI Project Trigger Noise Levels

Background noise levels were measured at the centre of Horsley Park Business Park Stage 1, prior to its construction, as part of the DA Acoustic Assessment as shown in **Figure 1**. It is considered that measurements undertaken prior to the construction commencing in the area are reasonable to inform the assessment as ongoing works would likely influence current noise levels in the area.

PTNLs for all noise sensitive receiver areas surrounding the Proposal have been established with reference to the prior measurements and are contained in **Table 5**.

Table 5 Project Trigger Noise Levels

Type of receiver	Noise amenity area	Time of day	RBL[1]	Project Intrusive[2] dBA	Project Amenity[3] dBA	Project Amenity[4] dBA	Resulting PTNL[5] dBA
				LAeq(15minute)	LAeq(period)	LAeq(15minute)	LAeq(15minute)
Residential	Urban	Day	51	56	55	58	**56**
		Evening	49	54	45	48	**48**
		Night	46	51	40	43	**43**
Commercial	All	When in use	n/a	n/a	n/a	65	**65**
Industrial	All	When in use	n/a	n/a	n/a	70	**70**

Note 1: Rating Background Level (RBL) as stated in *Horsley Park Business Park – Stage 2, DA Acoustic Assessment* prepared by Acoustic Logic in 2016

Note 2: Project Intrusive is the RBL plus 5 dB

Note 3: Project amenity (period) noise level is the Amenity Criteria minus 5 dB.

Note 4: Project amenity (15 minute) noise level is the Project Amenity (period) noise level plus 3 dB

Note 5: Resulting PTNL is the lower of the project intrusive and the project amenity (15 minute) noise levels

The relevant sleep disturbance noise goals for the Project are provided in **Table 6**

Table 6 Sleep Disturbance Noise Goals

Receiver	Period	RBL	SDNL L_{Amax}
Residential	Night	46	61

4.2.3 Road Traffic on Public Roads

For developments which increase the traffic on adjacent public roads, the EPA's NSW *Road Noise Policy* (RNP) applies guidance to assess potential impacts. The RNP provides non-mandatory criteria for residential and 'other sensitive' land uses. Where a project results in road traffic noise levels which are predicted to be above the criteria, the project should investigate feasible and reasonable noise mitigation measures to minimise the impacts.

In assessing feasible and reasonable mitigation measures, the RNP suggests that an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.

Table 7 Road Noise Policy Criteria

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
Freeway/ arterial/ sub-arterial roads	3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15\ hour)}$ 60 (external)	$L_{Aeq(9\ hour)}$ 55 (external)
Local roads	9. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq(1\ hour)}$ 55 (external)	$L_{Aeq(1\ hour)}$ 50 (external)

5 Predicted Noise Emissions

5.1 Prediction Methodology

A computer model was used to predict noise emissions from the operation of the Project. The operational noise modelling was undertaken using the ISO9613 algorithms within SoundPLAN v8.1 software. A three-dimensional digital terrain map providing relevant topographic information was used in the modelling process, together with noise source data, shielding by barriers and/or adjacent buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers.

Sound power levels and speed assumptions for the modelled vehicle movements are outlined in **Table 8**.

Table 8 Sound Power Levels for Onsite Vehicle Movements

Noise Source	Sound Power Level (SWL)	Average Speed
Heavy Vehicles	103 dBA[1]	25 km/h
Light Vehicles	96 dBA	40 km/h
Gas-powered Forklifts[2]	93 dBA	n/a

Note 1: Based on SLR's noise measurement database, this sound power level is typical of trucks travelling at low speeds, such as within industrial estates.

Note 2: If electric forklifts are proposed for the development, noise emissions from forklifts would be considerably lower than gas-powered forklifts.

Acoustic data for the fixed plant are outlined in **Table 9.**

Table 9 Sound Power Levels for Onsite Noise Sources

Noise Source	Sound Power Level (SWL) dBA	Quantity	Source
Data Room roof AC unit	91	4 per room (2 rooms total)	CRAC outdoor units, as specified in Paramount Airconditioning email
Compactor	70[1]	4	S1500 BLADE compactor datasheet
Office HVAC unit	84	3	PURY-P800, as specified in Paramount Airconditioning email
Refrigeration Condenser	95	3	As specified in Oomiak email
Warehouse roof HVAC	89	8	As specified in Paramount Airconditioning email
Wash Bay	85	4	Kärcher Model: TB50 See Note 2

Note 1: Assuming compactors are running concurrently for 1 minute in a 15-minutes period

Note 2: Based on attended measurements conducted by SLR on 05/02/2020 of a similar Karcher wash bay with the same configuration of the proposed wash bays of this project. The proposed wash bays are not equipped with high-pressure manual cleaning option and are not operating concurrently with the undertray spray option. The noise model assumed the washers orientated east-west entry/exit (ie the residence at 27 Trivet Street only looks at the sidewalls of the washers)

In addition to the above noise sources, heavy vehicle brake releases and reverse alarms (non-tonal) may occur within the hardstand areas of the development and along the heavy vehicle route. A maximum sound power level (SWL) of 118 dBA has been used to screen for potential sleep disturbance from L_{Amax} noise events on site.

5.2 Predicted Operational Noise Impacts

The predicted $L_{Aeq(15minute)}$ noise levels at the nearest residential receiver locations are presented in **Table 10**, **Table 11** and **Table 12** for the daytime, evening and night-time periods respectively.

Table 10 Predicted Operating Noise Levels - Daytime

Receiver	Type	Predicted Noise Level $L_{Aeq(15minute)}$ (dBA)	SSD7664 Criteria $L_{Aeq(15minute)}$	SSD10404 SEARs PTNL $L_{Aeq(15minute)}$
28 Trivet Street, Wetherill Park (82 Cowpasture Road, Wetherill Park)	Residential	48	52	56
34 Ferrers Road, Horsley Park	Residential	42	-	56
46 Ferrers Road, Horsley Park	Residential	42	-	56
70 Ferrers Road, Horsley Park	Residential	45	-	56
HDBP Stage 1	Industrial / Commercial	48	-	70/65
Wetherill Park Industrial Precinct	Industrial / Commercial	42	-	70/65

Table 11 Predicted Operating Noise Levels - Evening

Receiver	Type	Predicted Noise Level $L_{Aeq(15minute)}$ (dBA)	SSD7664 Criteria $L_{Aeq(15minute)}$ (dBA)	SSD10404 SEARs PTNL $L_{Aeq(15minute)}$ (dBA)
28 Trivet Street, Wetherill Park (82 Cowpasture Road, Wetherill Park)	Residential	44	49	48
34 Ferrers Road, Horsley Park	Residential	41	-	48
46 Ferrers Road, Horsley Park	Residential	40	-	48
70 Ferrers Road, Horsley Park	Residential	43	-	48
HDBP Stage 1	Industrial / Commercial	48	-	70/65
Wetherill Park Industrial Precinct	Industrial / Commercial	48	-	70/65

Table 12 Predicted Operating Noise Levels – Night-time

Receiver	Type	Predicted Noise Level $L_{Aeq(15minute)}$ (dBA)	SSD7664 Criteria $L_{Aeq(15minute)}$ (dBA)	SSD10404 SEARs PTNL $L_{Aeq(15minute)}$ (dBA)
28 Trivet Street, Wetherill Park (82 Cowpasture Road, Wetherill Park)	Residential	43	47	43
34 Ferrers Road, Horsley Park	Residential	41	-	43
46 Ferrers Road, Horsley Park	Residential	40	-	43
70 Ferrers Road, Horsley Park	Residential	43	-	43
HDBP Stage 1	Industrial / Commercial	48	-	70/65
Wetherill Park Industrial Precinct	Industrial / Commercial	47	-	70/65

The assessment presented in the above tables indicate that all daytime, evening and night operations are predicted to comply with the nominated noise criteria including PTNL criteria (SSD10404 SEARs) and the consent condition (SSD7664).

5.3 Sleep Disturbance

The predicted $L_{A1(1minute)}$ noise levels at the nearest residential receiver locations are presented in **Table 13** for the daytime, evening and night-time periods respectively.

Table 13 Predicted Operating Noise Levels – Sleep Disturbance

Receiver	Type	Predicted Noise Level $L_{A1(1minute)}$ (dBA)	SSD7664 Criteria $L_{A1(1minute)}$ (dBA)	SSD10404 Criteria PTNL L_{Amax} (dBA)
28 Trivet Street, Wetherill Park (82 Cowpasture Road, Wetherill Park)	Residential	60	57	61
34 Ferrers Road, Horsley Park	Residential	57	-	61
46 Ferrers Road, Horsley Park	Residential	56	-	61
70 Ferrers Road, Horsley Park	Residential	58	-	61
HDBP Stage 1	Residential	70	-	61
Wetherill Park Industrial Precinct	Residential	66	-	61

The results of the sleep disturbance assessment indicate a potential exceedance of the screening criteria which indicates a requirement for a detailed assessment. However, the predicted $L_{A1(1minute)}$ noise levels are conservatively based on the 118 dBA L_{Amax} and assumed that the noise events will be at the closest possible location to the receiver (180m).

Where those trigger levels are not met, it is appropriate to consider any effect of the noise with regard to:

- The extent to which the maximum noise level exceeds the rating background noise level
- How often high noise events will occur
- The distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the subject development
- Whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods)
- Current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

A review of research on sleep disturbance in the NSW *Road Noise Policy* indicates that in some circumstances, higher noise levels may occur without significant sleep disturbance. Based on studies into sleep disturbance, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions; and that
- One or two noise events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

Internal noise levels in a dwelling, with the windows open, are commonly 10 dB lower than external noise levels. Therefore, the first conclusion above suggests that short-term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions. The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

5.4 Traffic on Public Roads

The main access route to the development site is proposed via Cowpasture Road and Trivet Street. A comparison of existing traffic and future traffic generated by the proposed development is outlined in **Table 14.**

Table 14 Forecast Traffic Volumes on Public Roads

Road	Existing Traffic[1]				Site Generated Traffic[2,3]			
	Daytime (7 am - 10 pm)		Night-time (10 pm - 7 am)		Daytime (7 am - 10 pm)		Night-time (10 pm - 7 am)	
	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy
Trivet Street / Cowpasture Road (north of HDBP Stage 2)	4544	140	1515	47	299	32	96	23
Cowpasture Road (south of HDBP Stage 2)	6134	526	2045	175	1688	184	544	133

Note 1: Based on Austraffic survey dated 05/12/2019 for the daytime period. Night-time period traffic was assumed to be 25% of the daily total.

Note 2: The internal traffic assignment is assumed to be 85%/15% distribution between Cowpasture Road and Trivet Street as per Ason report Horsley Drive Business Park Stage 2, dated 02/12/2016 (reference: 0300r01v2)

Note 3: Site generated traffic volumes were supplied by the project team . The site traffic includes the proposed development, Lot 2 and Lot 3.

While light and heavy vehicle movements within the proposed development are classified as part of the operational site noise, once they move off the site and onto public roads they are assessed under the *NSW Road Noise Policy (RNP).*

The RNP requires noise mitigation to be considered where new land use developments increase road traffic noise by more than 2.0 dB. The traffic data in **Table 14** was used to calculate the traffic noise impacts using the procedure detailed in the *Calculation of Road Traffic Noise* (CoRTN) which was issued by the Department of Transport in 1988.

A summary of the potential noise impacts of road traffic on public roads is outlined in **Table 13**.

Table 15 Predicted Traffic Noise Levels on Public Road

Road	Speed (km/h)	Existing L_{Aeq} (dBA)		Combined L_{Aeq} (dBA)		Increase L_{Aeq} (dBA)	
		Day 15hr	Night 9hr	Day 15hr	Night 9hr	Day 15hr	Night 9hr
Trivet Street / Cowpasture Road (north of HDBP Stage 2)	60	64	61	64	62	0	1
Cowpasture Road (south of HDBP Stage 2)	60	66	64	67	65.4	1	2

Note 1: Noise levels are predicted at a nominal distance to understand the relative increase of the total noise contributed by the existing and site-generated traffic.

The predicted increase in road traffic noise due to the proposed facility is predicted to be not greater than 2.0 dB. Consideration of mitigation is not required as a result.

5.5 Cumulative Noise Impacts

It is noted that there are existing industrial areas in the vicinity of the proposed warehouse. To account for that, the recommended amenity criteria was reduced by 5 dBA as outlined in the NPfI (see Note 4 of **Table 5**). As such, it is considered that cumulative operational noise impacts from the development and the existing industrial noise sources would not result in an exceedance of the cumulative amenity noise criteria.

6 Recommended Mitigation

6.1 Site Noise Emissions

6.1.1 General

It is recommended that the following noise mitigation measures be put in place with a view to minimise noise levels from the Project:

- Briefing the work team and contractors to create awareness of the proximity of noise-sensitive residential receivers and the importance of minimising noise emissions.
- Using 'quiet' work practices to minimise noise, where possible.
- Use of less noise-intensive equipment, where feasible and reasonable.
- Adjusting reversing alarm volume on heavy equipment to make them 'smarter', by limiting the acoustic range to immediate danger area, where acceptable under the relevant safety procedures.
- Enclosure of outdoor fixed plant (such as mechanical plant) where practicable
- For equipment with enclosures, ensure door and seals are well maintained and kept closed when not in use.

Noise management and mitigation measures would be confirmed in an Operational Noise Management Plan (ONMP) – refer to **Section 7**.

7 Recommended requirements for the ONMP

The Operational Noise Management Plan (ONMP) would consider the finalised operations and confirm the appropriateness of the mitigation and management measures recommended in this assessment.

The ONMP would outline the management and control measures to manage noise impacts from the Proposal through a combination of following:

- Requiring best management practices to be implemented onsite by all staff and contractors.
- Implementing noise controls to reduce noise from the source and attenuate noise transmission.

The ONMP would include the following key components:

- Relevant Development Consent Conditions
- Details of the nearest noise sensitive receivers
- A list of major noise generating activities
- Details of the noise management measures, including noise monitoring requirements where necessary
- Details of how a complaints register and contingency plan would be implemented
- Details of internal audits
- Details regarding how review and improvement of Noise Management Plan would occur.

Attended noise monitoring would be undertaken by a suitably trained and qualified acoustic consultant. All attended noise monitoring will be conducted in accordance with the NSW *Noise Policy for Industry*.

APPENDIX A

Acoustic Terminology

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3. Sound Power Level

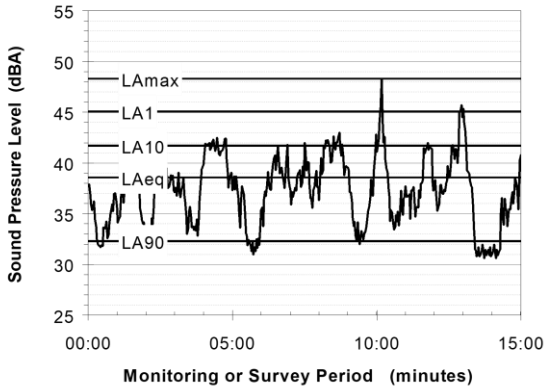
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

5. Frequency Analysis

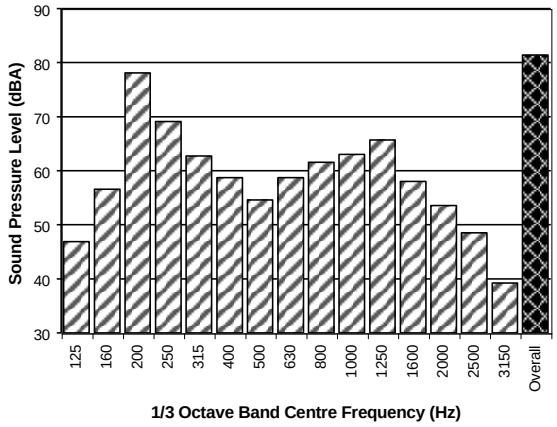
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (three bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

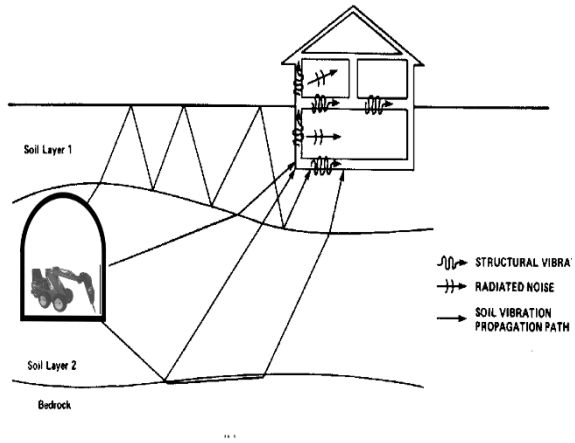
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

TOWNSVILLE SOUTH
12 Cannan Street
Townsville South QLD 4810
Australia
T: +61 7 4772 6500

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628